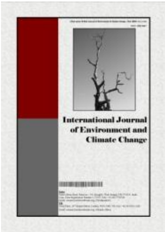

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# Yield Enhancement through a Low-Cost Irrigation System for Groundnut

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

The existing irrigation system namely drip and sprinkler adds cost to production. So, an alternate low-cost irrigation system (rain hose irrigation) was compared with other irrigation systems. The study was proposed to find out the optimum soil moisture by selecting a proper irrigation system that supports optimum soil moisture management, enhanced productivity, high water use efficiency, and also involves less cost on production. The treatment comprises different methods of irrigation (drip, sprinkler, rain hose, and BBF) and deficit irrigation (100%, 125%, and 75% of PET) was tested. The results have shown that higher pod yield (3086 kg/ha) and high water use efficiency (11.2 kg/ha.mm) were attained in drip + 100% of PET and drip + 75% of PET. The high B/C ratio was attained in rain hose + 100% of PET and hence, considered as the low-cost irrigation technology for higher profit.

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*Keywords: Groundnut; alternate irrigation system; rain hose irrigation; B/C ratio; higher profit; economics.*

## 1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important legume crop that belongs to the family of Leguminosae. Groundnut is cultivated mainly in the *Kharif* season. In some states, it is also cultivated in the *rabi* and *spring* seasons as an irrigated crop. The crop is especially valued for its high amount of oil (43-55%) and protein (25-28%) content.

India has been the world's leading producer of groundnut in an area of 6.01 m ha, having an annual production of 10.2 m t with annual average productivity of 1703 kg/ha (Indiastat 2020-21). It is the 6$^{th}$ most important oil seed crop after sunflower, sesame, etc. In Tamil Nadu, it is grown in an area of 0.409 m ha, having an annual production of 1.023 m t with annual productivity of 2500 kg/ha (Indiastat 2020-21). The water required by groundnut to complete its life cycle is around 500-700 mm [1], but the needed quantity of water varies from crop's several stages. Among all the agronomic factors, water management stands second which contributes yield next to fertilizer application of around 27%.

Out of the total cost of production, more than 40% of the cost involved seed input and it is not reflected in yield. The seed cost has not contributed to the yield factor because of higher mortality by unscientific soil moisture maintenance. The irrigation technology which has to support optimum soil moisture maintenance for the better establishment of crops to maintain the optimum plant population and support for high productivity by reducing mortality is essential.

Adopting appropriate irrigation management technologies which significantly influences the water use efficiency and improves productivity in a cost-effective manner. Those irrigation management technologies maximize productivity by providing adequate moisture to the crop during the crop growth stages [2].

In comparison with traditional irrigation practices, micro-irrigation systems play a crucial role in saving agricultural water use. The existing micro irrigation system namely drip and sprinkler adds cost to production and reduces profitability. The system which supports optimum soil moisture management and also involves less cost on production to be studied.

With this background, an alternate method of irrigation is recently available in the market (rain hose system of irrigation) was considered as one of the treatments and compared with the existing micro-irrigation systems with the objective.

- To find out the optimum soil moisture to avoid disease incidence
- To find out the best water management approach for higher productivity and higher profitability.

## 2. MATERIALS AND METHODS

### 2.1 Experimental Site

The field experiment was carried out during *rabi* season at Agricultural College and Research Institute, Madurai, Tamil Nadu, India. The initial soil sample has been taken for analyzing the nutrient content of the soil. The initial status of soil has low available nitrogen (246.4 kg/ha), medium available phosphorus (11.8 kg/ha), and high available potassium (478 kg/ha) respectively. The soil pH and Electrical Conductivity (EC) values were 7.55 and 0.18 dsm$^{-1et}$. The soil texture of the experimental field was sandy loam having a moderate infiltration rate of 2.25 cm/h.

### 2.2 Selected Variety

The variety selected for the experiment was VRI-8 (Virudhachalam 8), which was released by Regional Research Station (TNAU), Virudhachalam in the year 2016. It is a Spanish bunch type variety, with medium robust pods and rose-colored testa. It takes 105-110 days to reach full maturity.

### 2.3 Design of Experiment

The experimental design was a strip plot design which includes horizontal factor namely drip, sprinkler, rain hose, and broad bed and furrow (BBF) methods of irrigation and vertical factor includes deficit irrigation at levels of 100%, 125%, and 75% of PET and it was replicated thrice.

## 2.4 Methodology Involved

The irrigation was given to the crop once in three days intervals, and the quantity of water has been decided based on the pan evaporation method.

$$ET_O = E_{pan} \times K_p \quad (1)$$

Where,

$ET_O$ - Potential Evapotranspiration
$E_{pan}$ - Pan Evaporation (mm)
$K_p$ - Pan coefficient
$ET_O$ is the Potential Evapotranspiration; it was calculated by using the Class A pan evaporimeter.

The quantity of water that needs to be given was calculated at different levels of 100%, 125%, and 75% of PET by using the pan evaporation method, which was given to the crop through the drip, sprinkler, rain hose, and BBF method of irrigation systems. The application of the calculated quantity of water through different irrigation systems will be the same but the time taken to deliver the water has varied according to the irrigation system.

## 2.5 Water Use Efficiency

Water Use Efficiency (WUE) was a term that helps to evaluate deficit irrigation strategies. It is defined as the ratio of yield obtained to the volume of water utilized by the crop [3].

$$WUE = (\text{Yield } (Y_a)) / (\text{Volume of water } (ET_a)) \quad (2)$$

## 2.6 Economics

The market prevailing rates of varied inputs like seeds, fertilizers, and wages for the labourers and the available market rate of the produce at the local paid by the government have been considered while deriving the economics. The economics of the conventional method and micro irrigation systems also had been derived to calculate the net returns and B/C ratio.

# 3. RESULTS AND DISCUSSION

## 3.1 Yield Obtained

Among the irrigation combinations, the highest pod yield was obtained in drip irrigation + 100% of PET (3086 kg/ha) and was followed by rain hose irrigation + 100% of PET (2922 kg/ha), and it was at par with drip irrigation + 75% of PET (2856 kg/ha) which is briefly shown in the Table 1. The lowest yield was observed in the BBF + 125% of PET (1926 kg/ha). These findings were similar to the results given by Ranjitha et al*.* [4]. The increased pod yield in drip irrigation +100% of PET was due to the maintenance of optimum moisture throughout the growing season directly to the root zone which has a significant influence on the yield attributes like the number of pods/plant and providing adequate frequency of irrigation has kept the soil in optimum moisture condition with reduced disease incidence led to optimum plant population, when compared to other treatment combinations. These findings were similar to the results given by Ranjitha et al*.,* [4]. Hence, the contribution from an increased number of pods/plants, lower disease incidence, and sustained plant population boosted the drip + 100% PET to attain the highest yield when compared to all other treatments. The reason behind the similar results gained by rain hose + 100% of PET and drip + 75% of PET where the soil moisture content was estimated that the moisture of both the condition (rain hose + 100% of PET& drip + 75% of PET) is in optimum range which was reflected on the optimum plant population and all other yield factors are at par. The soil excess moisture is sensitive to groundnut leads to pest and disease incidence that causes disturbance in maintaining optimum plant population, so that pod yield could be reduced [5]. The water stress during the vegetative phase improved the synchrony of flowering resulted in more peg to pod conversion [6]. The drip irrigation method had greatly influenced the yield parameters like pod and haulm by [7]. The obtained results were similar to the reports given by [8].

## 3.2 Water Use Efficiency

Generally, getting high yield by lowering the quantity of water use would have higher water use efficiency, in that case drip irrigation had significantly increased the water use efficiency which is briefly shown in the Table 2. Drip irrigation + 75% of PET (11.2 kg/ha.mm) has been obtained with a result of the highest water use efficiency and which has been closely followed by rain hose + 75% of PET (10.7 kg/ha.mm) and the following treatment after that was sprinkler +75% of PET (9.6 kg/ha.mm) and the lower water use efficiency was attained by BBF + 125% of PET (4.5 kg/ha.mm). The obtained results were similar to the results by [9]. While using drip irrigation, enhancement of water use efficiency has been attained by avoiding percolation, runoff, and soil evaporation [10]. Drip + 75% of PET has given the higher water use efficiency, as the quantity of water has been utilized effectively through direct root zone application to the crop with reduced evaporation losses decreased the water use which attained a high pod yield per hectare mm of water applied [10]. The maximum water use efficiency can be achieved under deficit condition as compared to optimum moisture condition due to effective usage of each droplets for the conversion of pod is high [11].

### 3.3 Economics

The cost of cultivation, gross return, net return, and benefit-cost ratio were briefly shown in the Fig. 1. Among the irrigation management practices, drip irrigation + 100% of PET (₹ .2,25,429.79/ha) had the highest net return, which was closely followed by rain hose irrigation + 100% of PET (₹. 2,15,506.00/ha) and followed by drip irrigation at 75% of PET (₹ .2,03,390.29/ha), and the lower value of net return was attained in BBF + 125% of PET (₹ .1,26,087.50/ha). The highest net return in drip irrigation + 100% of PET was also attributed to the highest gross return (₹ .2,85,043.50/ha).

**Table 1. Effect of different methods of irrigation and deficit irrigation levels on Pod yield (kg/ha)**

| Treatments | Pod Yield (kg/ha) | | | Mean |
|---|---|---|---|---|
| | Deficit irrigation levels | | | |
| | 100% | 125% | 75% | |
| **Drip** | 3086[a] | 2440[d] | 2856[b] | **2794** |
| **Sprinkler** | 2598[c] | 2293[e] | 2442[d] | **2444** |
| **Rain hose** | 2922[b] | 2346[e] | 2718[c] | **2662** |
| **BBF** | 2037[f] | 1926[f] | 1987[f] | **1983** |
| **Mean** | **2582** | **2151** | **2435** | **2389** |
| | **I** | **S** | **I x S** | **S x I** |
| **SEd** | **31.92** | **29.98** | **46.97** | **43.75** |
| **CD (0.05)** | **65.17** | **60.99** | **121.92** | **118.86** |

*a-the highest, f - the lowest, b, c, d, e - performance in descending order*
*I – Different methods of irrigation (Drip, Sprinkler, Rain hose, and BBF) – Horizontal factor*
*S – Deficit irrigation levels (100%, 125% and 75% of PET) – Vertical factor*
*I x S – Interaction between Horizontal and Vertical factor*
*S x I – Interaction between Vertical and Horizontal factor*
*SEd – Standard deviation, CD (0.05) – Critical Difference at 5% probability*

**Table 2. Effect of different methods of irrigation and deficit irrigation levels on water use efficiency (kg/ha.mm)**

| Treatments | Water Use Efficiency (kg/ha.mm) | | | Mean |
|---|---|---|---|---|
| | Deficit irrigation levels | | | |
| | 100% | 125% | 75% | |
| **Drip** | 9.1[d] | 5.7[h] | 11.2[a] | **8.7** |
| **Sprinkler** | 7.6[f] | 5.4[h] | 9.6[c] | **7.5** |
| **Rain hose** | 8.6[e] | 5.5[h] | 10.7[b] | **8.3** |
| **BBF** | 6.0[g] | 4.5[i] | 7.8[f] | **6.1** |
| **Mean** | **7.7** | **5.2** | **9.6** | **6.8** |
| | **I** | **S** | **I x S** | **S x I** |
| **SEd** | **0.046** | **0.058** | **0.050** | **0.047** |
| **CD (0.05)** | **0.25** | **0.27** | **0.39** | **0.35** |

*a-the highest, i - the lowest, b, c, d, e, f, g, h - performance in descending order*
*I – Different methods of irrigation (Drip, Sprinkler, Rain hose, and BBF) – Horizontal factor*
*S – Deficit irrigation levels (100%, 125% and 75% of PET) – Vertical factor*
*I x S – Interaction between Horizontal and Vertical factor*
*S x I – Interaction between Vertical and Horizontal factor*
*SEd – Standard deviation, CD (0.05) – Critical Difference at 5% probability*

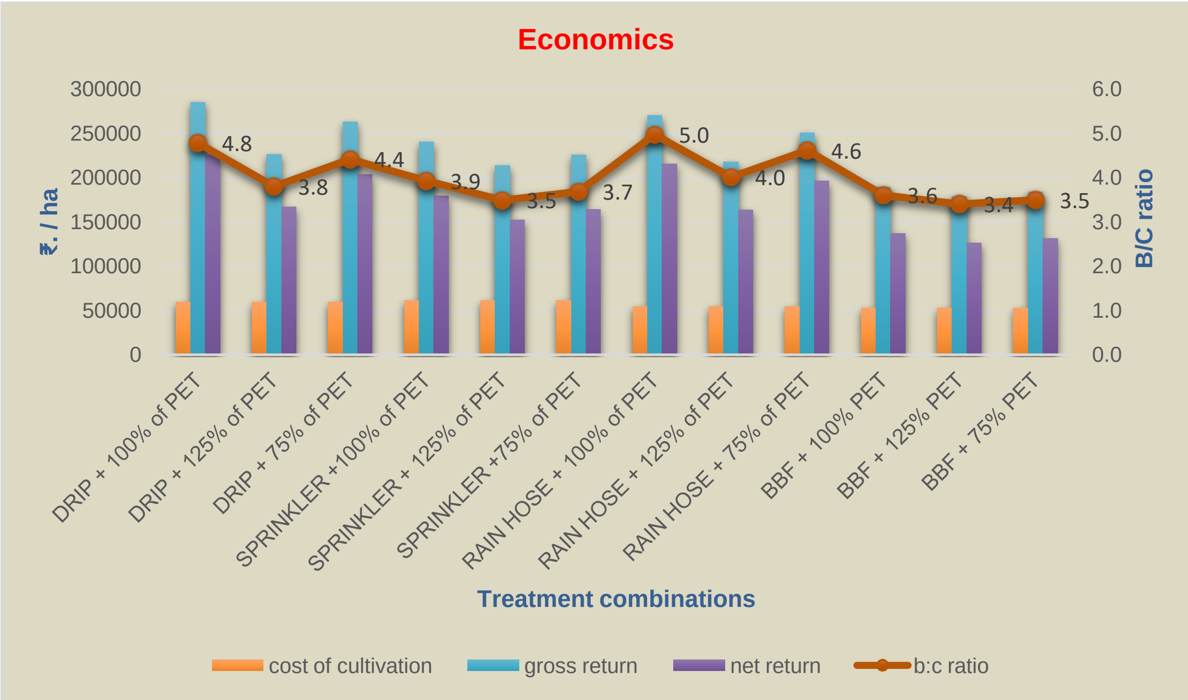


**Fig. 1. Impact of different methods of irrigation and deficit irrigation levels on economics**

Though drip irrigation + 100% of PET attributed to the highest net return, rain hose irrigation + 100% of PET records the highest B/C ratio (5.0) as its cost of cultivation was low when compared to drip installation. The installment cost has been higher in drip irrigation system. The B/C ratio was closely followed by drip + 100% of PET (4.8) and by rain hose irrigation + 75% of PET (4.6) and the lowest net return and the B/C ratio were obtained in the BBF+ 125% of PET (3.4). The B/C ratio of rain hose + 100% of PET was high due to less installment cost when compared to other irrigation systems and the increased pod yield.

## 4. CONCLUSION

The higher productivity (3086 kg/ha), high water use efficiency (11.2 kg/ha.mm) was achieved in drip + 100% of PET and drip + 75% of PET. However, the higher pod yield has not resulted in higher profitability. Hence, the low-cost irrigation technology (rain hose system of irrigation) with optimum moisture level has attained the highest B/C ratio (5.0). Thus, the experimental result has been concluded that the low-cost irrigation technology i.e., rain hose + 100% of PET has given a better performance when compared to all other irrigation systems and farmer's practice.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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